# ASPHALT BINDER

## Section 5 – Marshall Mix Design

# Mix Design-Marshall Method

- **Test Procedure – AASHTO T 245 (Wyoming Modified)***
- **General**
  - **4 inch ϕ x 2.5 inch specimens**
  - **Same aggregate blend**
  - **Varying binder content**
  - **Multiple specimens at each binder content**
- **Components**
  - **Bulk Specific Gravity Measurement**
  - **Density – Voids Analysis**
  - **Stability – Flow Test**

# Procedure

- **Sample Preparation**
  - **Obtain representative Asphalt and Aggregate Samples**
    - **Proposed for Use**
  - **Dry Aggregate**
    - **230°F**
    - **Constant Weight**
  - **Conduct Sieve Analysis**
  - **Determine S.G. of Aggregate and binder**

# Procedure (continued)

- **Prepare Mix Samples**
  - **Select binder Content Range**
  - **Heat binder and Aggregate to mix temperature specifications**
  - **Combine binder and Aggregate**
  - **Mix to thoroughly coat**
  - **Cure 2 hours at compaction temperature (Wyoming modified)**
  - **Place in heated molds**

# Procedure (continued)

- Compact with Marshall Hammer
  - 10 lbs
  - 18” drop
  - 50 or 75 blows per side
- Cool and remove for molds

# Marshall Compactor

# Procedure (continued)

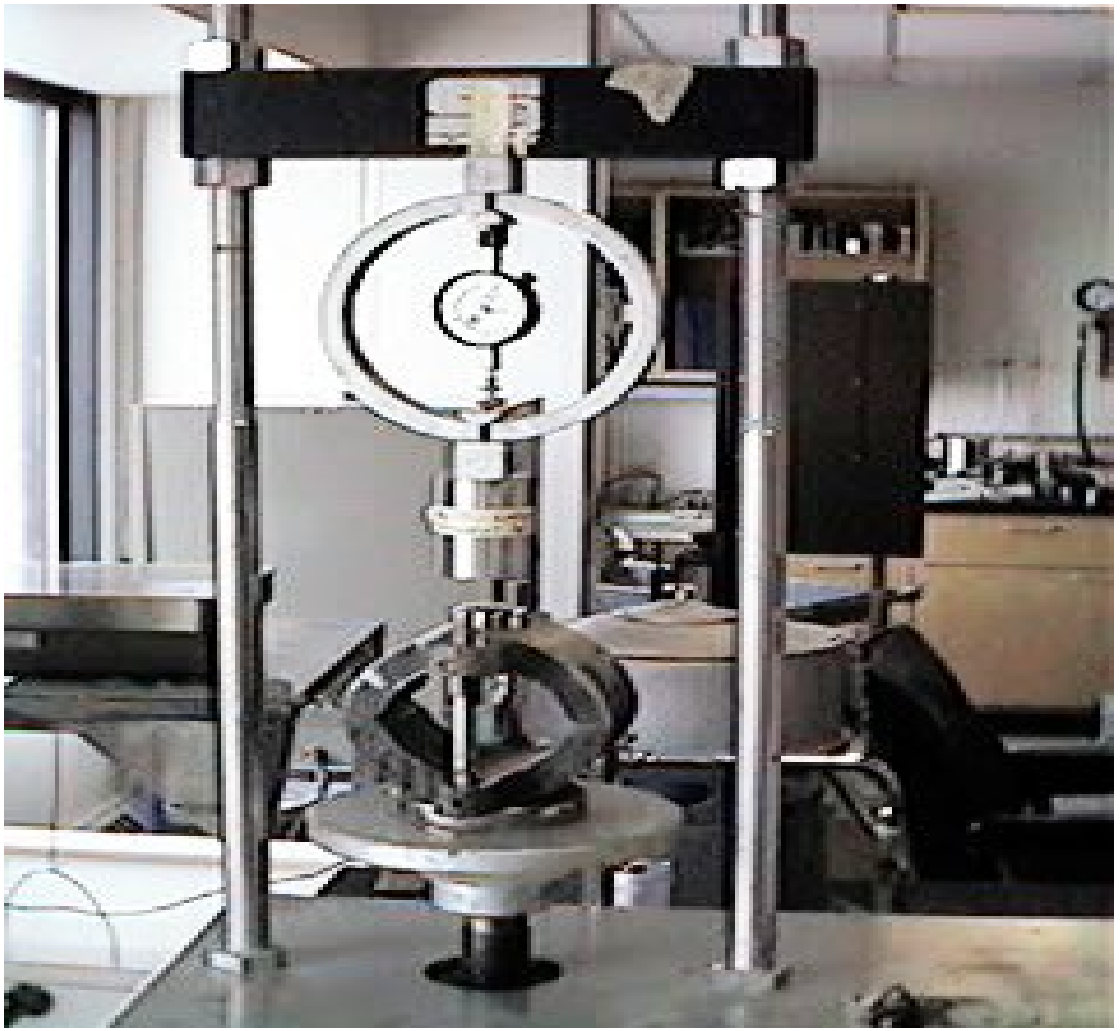
- **Testing**
  - **Measure Bulk S.G. of samples**
    - **AASHTO T 166**
    - **Weight in air – dry mass**
    - **Immerse in water 3 – 5 minutes and determine mass in water**
    - **Remove and blot dry with damp cloth**
    - **Weight immediately – SSD mass**
    - **Calculate Bulk S.G.**

$$BULK\ S.G. = \frac{dry\ \ mass}{(SSD\ mass - mass\ in\ water)}$$

# Procedure (continued)

- **Measure Stability And Flow Of Samples**
  - **Immerse in water - 140°F, 30 minutes**
  - **Remove from water and place in Marshall Tester**
  - **Apply load to failure**
    - **2 inches per minute**
  - **Record Stability – failure load**
  - **Record Flow – 0.01 inch**
  - **Complete in < 30 seconds**

# Marshall Stability Device



# Procedure (continued)

- **Analyze Density And Voids**
  - **Calculate Density**
  - **Calculate Air Voids**
  - **Calculate VMA**
  - **Calculate VFA**

# Procedure (continued)

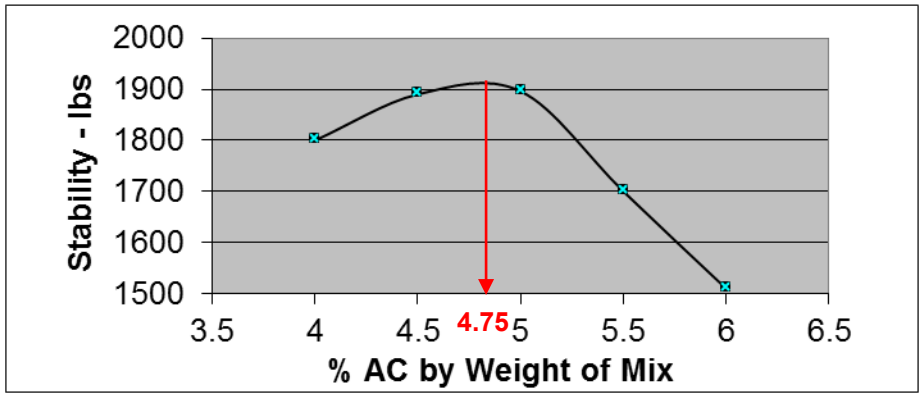
- **Plot Test Results Versus Asphalt Content**
  - **Stability**
  - **Air Voids**
  - **Density**
  - **Flow**
  - **VMA**

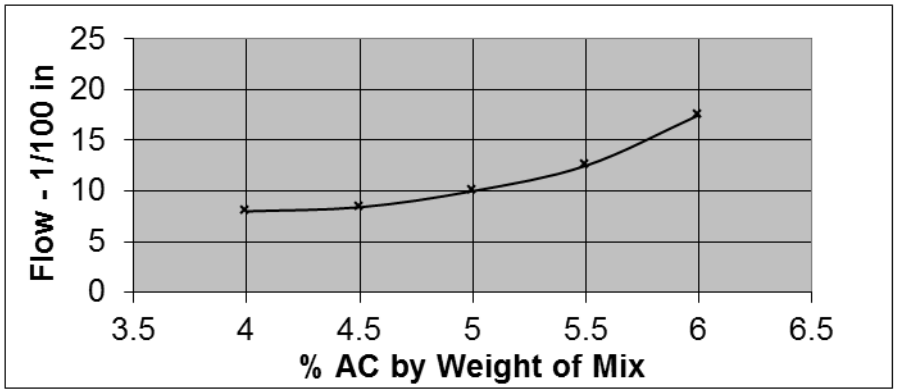
# Procedure (continued)

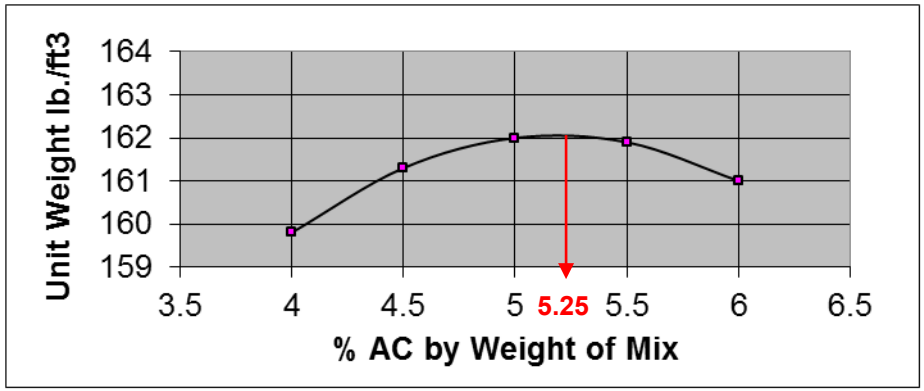
- From Plots, Find Binder or Asphalt Content At:
  - Maximum Density
  - Maximum Stability
  - 4% Air Voids
- Calculate Average
- Determine Characteristics at Average
- Compare vs. Criteria
- Select Binder Content

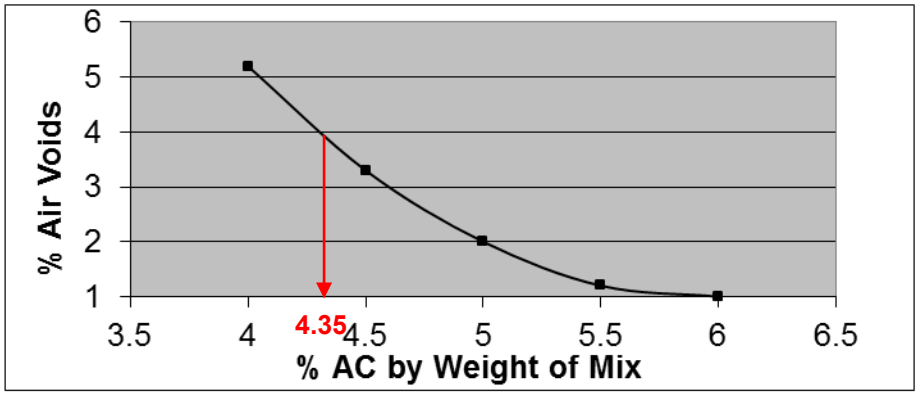
Maximum Density
Maximum Stability
4% Air Voids

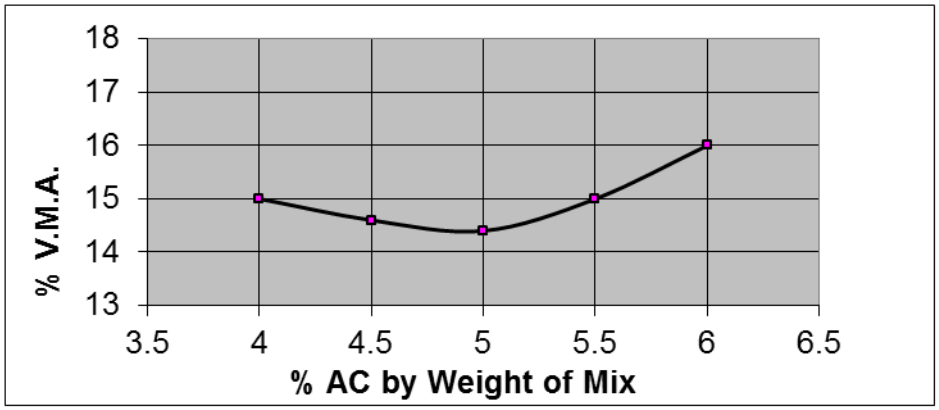
# Marshall Graphs




**Example:**

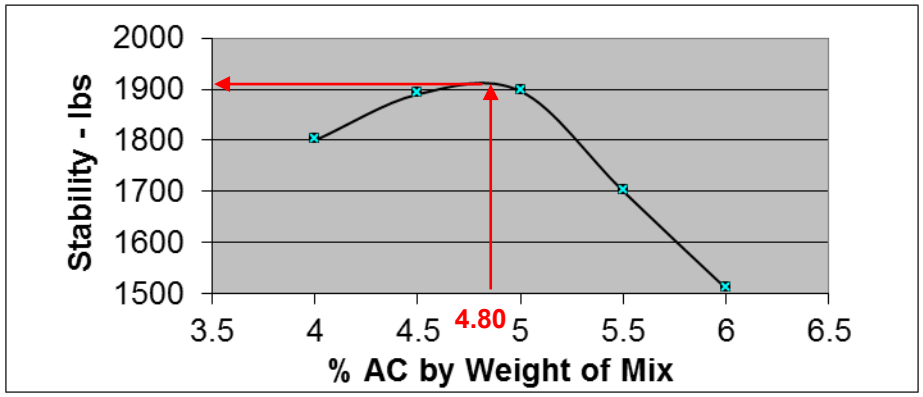
Max Density- 5.25% AC

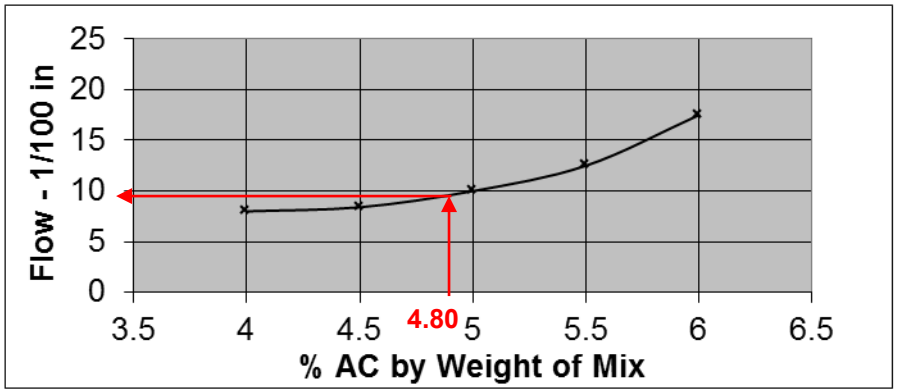
Max Stability- 4.75% AC

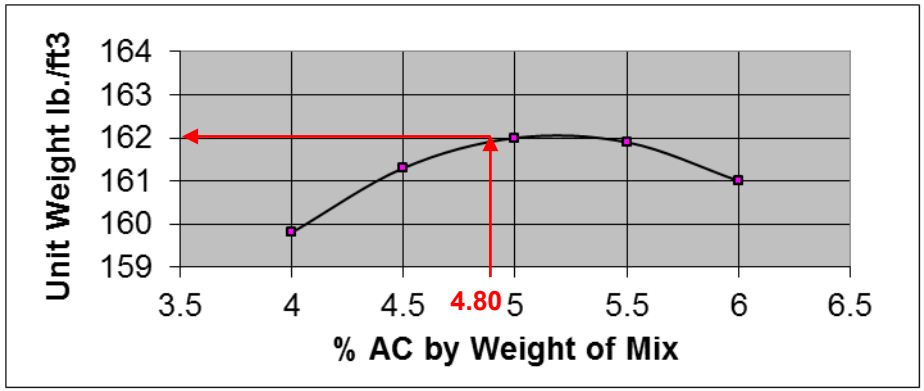
4% Air Voids- 4.35 % AC

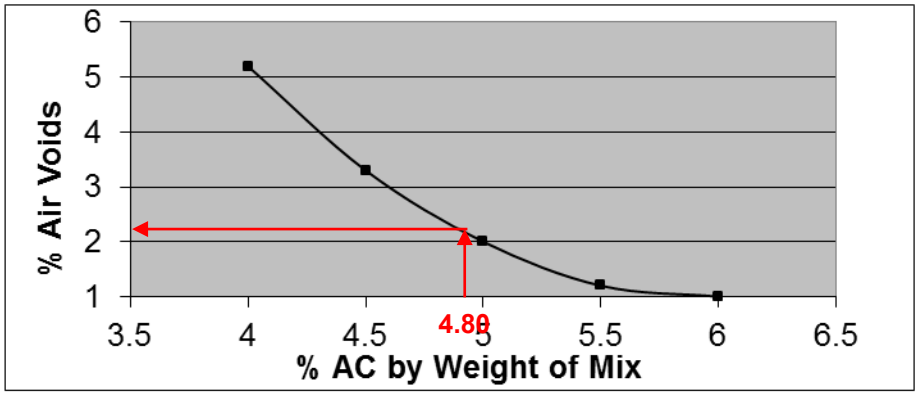
Avg of above = 4.8% AC

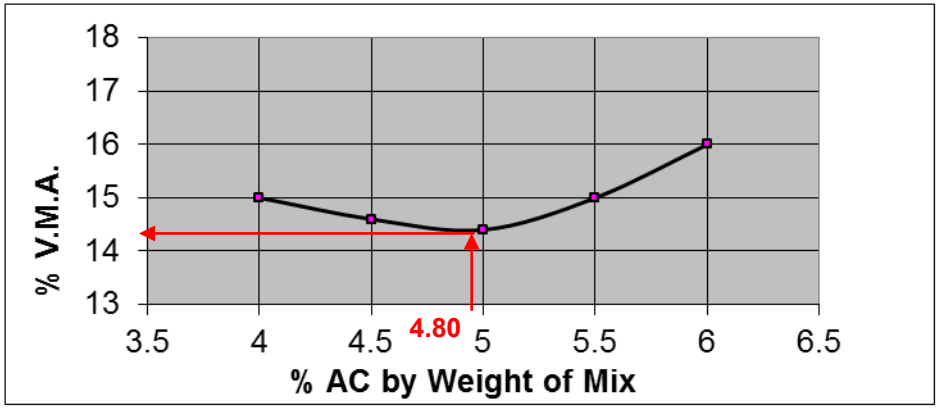
# Marshall Graphs




**Example Continued: Use 4.80% AC**

Density with 4.8% AC = 162 lb/ft$^3$

Stability with 4.8% AC = 1910 lbs

Air Voids with 4.8% AC = 2.1 %

Flow with 4.8% AC = 9.9 1/100in

VMA with 4.8% = 14.3%

Compare to Mix Design Criteria

# Marshall Mix-Design Criteria

## Table 401.4.1-2

| | Class I-M | Class II-M | Class III-M |
|---|---|---|---|
| Number of Marshall Blows | 75 | 75 | 50 |
| Marshall Stability (lbs [N]) minimum 1910 - Fail | 2500 [11000] | 2500 [11000] | 2000 [9000] |
| Marshall Flow (0.01 in [0.25 mm]) 14.3 - Pass | 8-16 [8-16] | 8-16 [8-16] | 8-16 [8-16] |
| % Voids in Laboratory Mix 2.1 - Fail | 5.0-6.0 | 4.0-5.0 | 4.0-5.0 |
| % Voids in Production Mix | 4.0-6.0 | 3.0-5.0 | 2.5-5.0 |
| Dust/Effective Asphalt | 0.8-1.4 | 0.8-1.4 | 0.8-1.4 |
| Minimum % Asphalt 4.8 - Pass | 4.5 | 4.5 | 4.5 |
| Minimum Tensile Strength Retained % | 75 | 75 | 75 |
| Film Thickness μm | 6-12 | 6-12 | 6-12 |

# Percent Voids in Mineral Aggregate (VMA)

## Table 401.4.1-3

| | 1 in Maximum Nominal Size | ¾ in Maximum Nominal Size | ½ in Maximum Nominal Size | 3/8 in Maximum Nominal Size |
|---|---|---|---|---|
| | 9.9 - Fail | Laboratory Mix | | |
| CLASS IM, IIM | 12.0-15.0 | 13.0-16.0 | 14.0-17.0 | 14.0-17.0 |
| CLASS IIIM | 11.0-14.0 | 12.0-15.0 | 13.0-16.0 | 13.0-16.0 |
| | | Production Mix | | |
| CLASS IM, IIM | 11.0-15.0 | 12.0-16.0 | 13.0-17.0 | 13.0-17.0 |
| CLASS IIIM | 10.0-14.0 | 11.0-15.0 | 12.0-16.0 | 12.0-16.0 |

Due to Fails -- Need to Redesign Mix

# Mix Design- Moisture Resistance

## Test Procedure – AASHTO T 283

**Procedure**

- Mix samples at Marshall Design AC Content
- Cure 16 hours at 140°F
- Heat to compaction temperature
- Compact to 7.0 ± 0.5% air voids with Marshall hammer
- Remove from molds and cure in air for 24 ± 3 hours
- Divide into two subsets

# Mix Design-Moisture Resistance (continued)

- **Procedure**
  - Test one subset in indirect tension
  - Condition other subset
    - Vacuum saturate to 70% to 80%
    - Freeze 16 hours at 0°F
    - Immerse in water 24 hours at 140°F
  - Immerse in water bath 1 hour at 77°F
  - Test in indirect tension
  - Calculate % retained strength

$$\frac{\text{Conditioned Subset Average Strength}}{\text{Unconditioned Subset Average Strength}}(100) = \%\ \text{Retained Strength}$$

WYDOT – greater than 80% retained